TEACHING CHEMISTRY THROUGH EXPERIMENTS

(A PROCESS APPROACH)

AT SECONDARY LEVEL

REGIONAL COLLEGE OF EDUCATION
National Council of Educational Research and Training, Bhubaneswar
1994 - 95

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NCERT

Materials developed in the workshop
held at R. C. E. Bhubaneswar
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DR. S. K. MOHAPATRA
Programme Director
DEPARTMENT OF SCIENCE

FORWARD

One of the most effective techniques for teaching and learning of Science at Primary/Secondary level is to create conditions in which the child is made to experience the thrill of a scientist and the scientific process itself. The teacher's role has to be that of a facilitator. The child has to be helped in cultivating the spirit of scientific enquiry so that he/she may use his/her creative potential in discovering facts, principles and applications all by himself.

Keeping this in view, the College has conducted the Programme entitled "Teaching Chemistry through experiments - a Process approach" for teachers and teacher educators of the States of Orissa and Bihar from 28.11.94 to 3.12.94.

It will be a pleasure for any one to go through the materials prepared in this programme. Dr. S.K. Mohapatra, Programme Co-Ordinator, the Resource persons and the participants deserve commendation for their sincere effort and hard work which culminated in the form of this useful and thought provoking experimental material. Suggestions forfurther improvement of this material are welcome. It is hoped that the reader would find this material meaningful, enriching and enjoyable.

PRINCIPAL

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My thanks are due to my collegues in the Department for their kind cooperation.

Last but not the least I thank all the participants for their active participation in making the programme a success.

(Dr.S.K. Mohapatra)
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PROCESS APPROACH

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Process approach is one of the several "inquiry" approaches advanced by American association for advancement of science in the sixties for teaching science at elementary and primary levels. The major goals of the programme is to develop in the learner the skills of observing, measuring, classifying, logical thinking, inferring/predicting/formulating a hypothesis and verifying the hypothesis followed by generalising. The learner is made to learn think and work as a scientist, the emphasis being "how he learns is more important than what he learns". The steps involved in the process are:

1) defining a problem
2) analysis of the problem
3) hypothesis (possible solution to the problem
4) Designing or imagining an experiment to prove the hypothesis.
5) Generalisation/modification of the hypothesis in the light of the experiment if necessary
6) verification/prediction.

To illustrate the meaning and significance of each of the steps, the work of Louis Pasteur can be cited.

1. Defining and Identifying a Problem:

This could be an unusual happening or some observation which needs explanation.

Louis Pasteur was a pure scientist when he joined the University of Lille in France. One of the principal industries in Lille was the production of alcoholic beverages. Monsieur Bigo, a leading manufacture of alcohol by formentation of beat juice faced a serious problem. Many à times his alcohols used to get contaminated with an unknown substance evenwhen the same method, the same procedure was applied everytime. No satisfactory explanation for the contamination could be found. Louis Pasteur was requested to find out the cause of contamination.

2. Analysis of the problem:

In the light of informations known or informations that can be gathered through more careful observations under controlled conditions followed by measurement classification (looking for regularity).

Pasteur having no knowledge of the problem, did not like to make a wild guess. He went to the alcohol factory, spent a great deal of time, observed everything he could, brought samples of the product studied them in a polarimeter, observed them under microscope and found small particles other than the known particles of yeast. He analysed his observations as follows:

(1) Yeast is a catalyst in the fermentation (already known).

(2) Some other particles which did not look like yeast.

(3) Fermenting beat juice was optically active and the alcohol produced is also optically active.

(4) Organic compounds, that are optically active, came from living things he had found out earlier. Yeast must be a living organism and responsible for fermentation.

3. Formulating a hypothesis:

Formulating a hypothesis before gathering sufficient information is unscientific. We learn in terms of what we already know and understand. It is in this frame of reference, we look at a problem. Facts are to be used to prove what we do not know and if what we know can not be used to prove the unknown, the knowledge is either inadequate or incorrect.

Pasteur's hypothesis:

"Contamination is due to the other micro-organism coming from air". (This was contradiction of Aristotelian view - the theory of spontaneous generation).

4. Designing an experiment

In order to ma-ke a hypothesis acceptable it has to be tested and proved beyond doubt, Pasteur had to prove two things.

1) the contamination is due to another micro-organism;
2) it came from air, First if the contamination is due to a living micro-organism it must grow and multiply by proper feeding and can be moved from place to place.

Pasteur experimented with milk and found that milk ferments (sours) rapidly if left at room temperature for a long time. (The sour taste is due to formation of lactic acid) and the ~~fermented~~-milk contained many microscopic organisms that looked alike. He also showed that by feeding these micro-organism milk, sugar they increased in number and they could be moved to a fresh sugar solution which soured much faster.

To prove that the undesirable micro-organism in spoiled alcohol came from air, he allowed fermentation to be carried on in specially designed goosenecked flask which does not allow micro-organisms to get into the flask from air, but allows air. Further he also showed that when the sugar solution is fermented protecting it from air, the resulting alcohol is not spoiled.

Generalisation:

Life begets life i.e. the micro-organism can not come from nonliving materials.

Verification/Prediction:

This is an important part of the process of science but it is only a part for rigorous testing of the hypothesis.

Pasteur himself asked if his findings were true, then it should hold good in case of formentation leading to formation of beer and vinegar also. He proved the presence of the some micro-organism in spoiled beer and vinegar and confirmed his generalisation.

Becquerels discovery of radioactivity can be told to illustrate the methods of science and make the students understand the nature of science.

Students at the Secondary level are not skilled scientists. A practicing scientist identifies his own problems, or takes up problems of the industry, society which need to be solved. Therefore, the teacher has to create situations which may lead his pupils to investigate. Our aim is to make him understand the process of science and provide the joy of discovery of facts, principles and generalisation. We probably think that Secondary school students can not be expected to discover anything new, different or original. We may be right, but think of the world that surrounds a learner that is known to the teacher but not to the student. If we lead him to discover this world - what he discovers will not be original or new to us but new and original to him. But how to go about it ? May be we have to start with a laboratory, experience or a very common observation known to the students.

Reference:

1. "Teaching of Science in the Secondary school",
   John, W Renner & Dong, Stanfford, Harper & Row
   Publishers, New York.

AN ILLUSTRATION: "BURNING OF A CANDLE"

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CONCEPT TO BE DEVELOPED: "Conservation of mass in a Chemical change".

OBSERVATION:

A candle is lighted. As the candle burns some heat is produced, light is given out. The candle if allowed to burn in open for sufficient time it appears to vanish leaving a small bit of wick only.

IDENTIFICATION OF PROBLEM:

What happens to the Wax of which the candle is made up of? Can mass be destroyed ?

GATHERING OF INFORMATION:

(Through discussion the teacher elicits the following information).

1) air is made up of oxygen, nitrogen and small amount of CO_2 and other gases;
2) Wax is made up of carbon and hydrogen;
3) Phosphorous, sulphur, magnesium burn in oxygen to form oxides, which can be identified by their smell, smoke or residue;

4) Hydrogen can burn in oxygen to form water.

5) Carbon also burns in oxygen to form carbon dioxide.

6) CO_2 turns like water milky

7) H_2O is absorbed by anhydrous (fused) calcium chloride or silica gel.

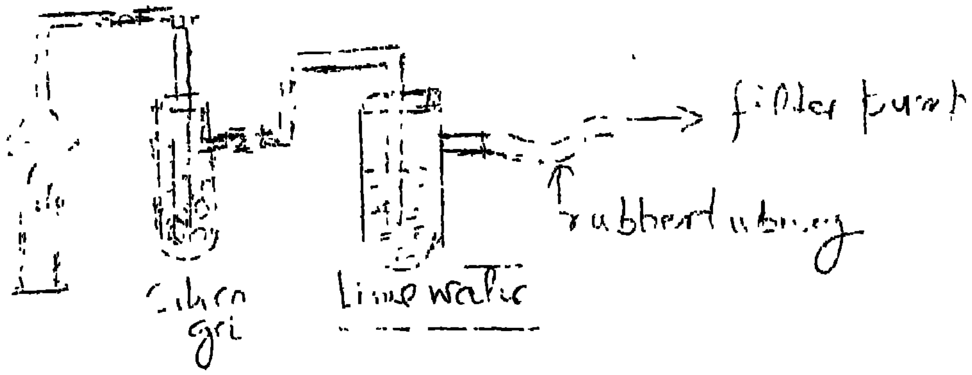
HYPOTHESIS:

When wax burns, CO_2 and H_2O are formed, both being colourless, Can not be observed. CO_2 and H_2O so formed diffuse into the atmosphere and disappear.

DESIGNING AN EXPERIMENT:

(1) to prove CO_2 and H_2O are formed during burning;

(2) to prove there is no loss of mass (students may suggest these experiments when sufficiently motivated).

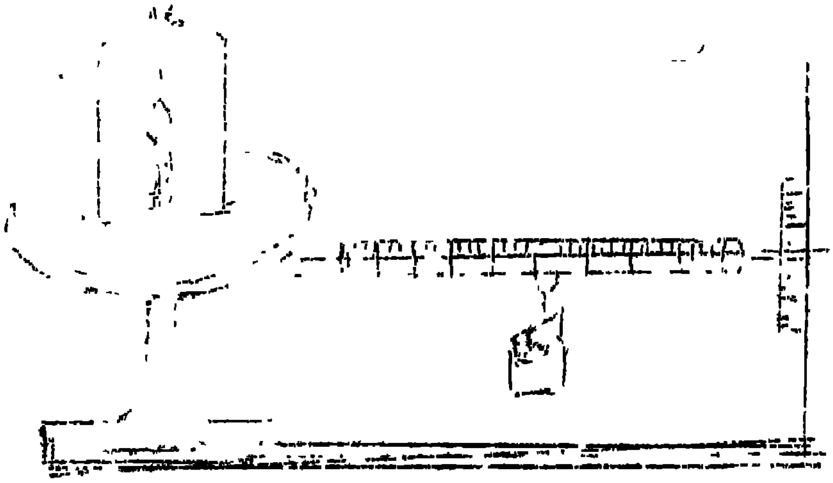


EXPERIMENT-1:

Set up the arrangement shown in the diagram. When the products of burning are sucked in for sometime, lime water turns milky and silica gel changes colour.

EXPERIMENT-2:

The candle is allowed to burn inside a bell jar on the pan of the balance as shown in the figure below.



Weights before lighting the candle and after the candle is extinguished and the whole arrangement comes to room temperature, are determined. (a few water droplets on the cooler part of the bell jar and a little soot may be observed.

GENERALISATION:

"There is no loss in mass in a chemical change".

VERIFICATION:

If the above generalisation is true it should hold good in case of any chemical change. Let us see what happens when the following reaction takes place.

$BaCl_2 + H_2 SO_4 \longrightarrow Ba SO_4 + 2 HCl$

Take about 10ml of dilute solution of $BaCl_2$ in a conical flask. Suspend a test tube (small size) containing 5ml of dilute sulphuric acid as shown by means of a thread. Weigh the flask with the contents using a spring balance. Then release the thread to allow the solutions to mix. Determine the mass of the flask with its contents again.

What do we find ?

Further verification can be done with the reaction $2KI + Pb (NO_3)_2 \longrightarrow PbI_2 + 2K NO_3$

If there is an activity you wish the learner should experience to develop a perticular concept or generalisation (when no one in the class initiates), the teacher can suggest the same. Researches indicate that probably as much intellectual development can take place in a teacher suggested activity as in one which the learner himself suggests.

Finally, it is however to be kept in mind that the approach is not the only effective way to teach science and all the steps can be strictly adhered to.

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CHANGES, THAT TAKE PLACE AROUND US - A CLASSIFICATION

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Observation and classification to find regularity or a pattern so as to enable the observer to predict on the basis of his information (generalisation) is the first step in any scientific process. It is intended to illustrate the same here.

(1) We burn various kinds of materials as coal, kerosene, petrol, to get heat and light - right from the kitchen to factories, locomotives to automobiles.

(2) Certain articles when left exposed to atmospheric/weathering conditions, get rusted and spoiled (iron rusts, milk gets sour).

(3) There are many solid substances, which when heated melt and on further heating vapourise. On cooling the melt or vapours, we get back the solid substances. (ice, wax, camphor).

(4) There are some substances which when added to water, simply dissolve and on evaporating the solution, we get back the substances (solution of salt and sugar).

QUESTION TO WONDER ABOUT:

Can we cla-ssify these changes to a few broad groups on the basis of certain regularities and make some generalisations.

Let us find out.

TEACHER'S SUGGESTED ACTIVITIES AND OBSERVATION:

(a) Take a small cube of ice on a plate. Keep it on the table for a few minutes. It melts. Put back the molten ice back in the refrigerator. It solidifies again.

(b) Take a small amount of Wax/sulphur in a test-tube. Warm it gently. They melt and reappear on cooling.

(c) Dissolve a small amount (table spoon) of salt/sugar in about 50ml of water. Stirr it. The salt/sugar disappears. Evaporate a portion of the solution in a china basin. Salt/sugar reappears.

(d) Heat a piece of nichrome wire/platinum wire till it becomes red hot. Cool the wire. The piece of wire regains its original state.

CONCLUSION:

(a) All the above changes are easily reversible i.e. they can take place in either way.

(b) No new substance is formed at the end of such changes.

LET US LOOK INTO THE FOLLOWING CHANGES:

(i) When a candle burns inside a closed tall gas jar or an inverted belljar, carbon dioxide and water are formed (CO_2 turns lime water milky).

(ii) When a small quantity of sulphur taken in a deflagrating spoon is burnt, a suffocating gas is produced (SO_2 decolourises acidified $KMnO_4$ solution) which when dissolved in water turns blue litmus red (Acidic).

(iii) When a piece of Magnesium is burnt, a white powder of magnesium oxide is formed which when dissolved in water turns red litmus paper blue. (Alkaline).

(iv) When copper turmings are heated with sulphur powder, Copper sulphide is formed which when treated with dilute HCl, a bad smelling gas is given out which produces black stains on a piece of filter paper soaked in lead acetate solution.

(v) When a Zinc foil is placed in $CuSO_4$ solution colour of copper sulphate is discharged.

Through this colourless solution when H_2S is passed. A white precipitate of ZnS is obtained.

(vi) When a few pieces of copper turnings are placed in $AgNO_3$ solution taken in a test-tube the solution turns blue gradually and shining particles of silver are found to be deposited on the copper turnings.

(vii) When H_2S is passed through a solution of Copper sulphate, a black ppt is obtained and the blue colour is discharged.

(viii) When, to a solution of sodium chloride, silver nitrate solution is added a White precipitate is formed.

(ix) When to a solution of barium chloride, dilute H_2SO_4 is added,. a white precipitate is obtained.

(x) To a solution of sodium hydroxide, 1-2 drops of phenolphthalein indicator is added. A pink colour is produced. The pink colour disappears suddenly when a certain amount of HCl is added to this (Phenolphthalein just indicates the extent of reaction).

CONCLUSION:

In the above experiments, we observe

(1) Either a gas is produced or a precipitate is formed or a colour change takes place which indicates a change taking place in the original substance.

(2) None of the above changes can be reversed, i.e. (i) Carbondioxide and water can not combine back to produce wax; (ii) SO_2 can not change back to sulphur; (iii) the white residue can not give back magnesium; (iv) the precipitate formed in VII, VIII, IX can't form back $CuSO_4$, $NaCl$ or $BaCl_2$ solutions respectively.

(3) New substances are formed in all such cases (i) to (x).

(4) Such changes are different from the first set of changes and are known as chemical changes.

Do all chemical changes are alike or they can be further classified ? What are the processes by which elements are changed to Compounds what are the processes by which compounds are transferred into new or different substances? Let us look back into the reactions again.

Changes (i) to (vi) can be represented by chemical equations as

(i) $C + O_2 \text{ (air)} \longrightarrow CO_2$

(ii) $S + O_2 \longrightarrow SO_2$

(iii) $2Mg + O_2 \longrightarrow 2Mg\ O$

(iv) $Cu + S \longrightarrow CuS$

(v) $Zn + Cu\ SO_4 \longrightarrow Zn^{++}SO_4^{=} + Cu$

(vi) $Cu + 2AgNO_3 \longrightarrow Cu^{++}(NO_3)_2^{=} + 2Ag$

In all these reactions, there is a change in the valency state or (Oxidation state of the reacting substances or ions, the oxidation state of elements in elemental state taken as zero. Such reactions are called oxidation reactions. Carbon sulphur, magnesium change from zero oxidation state to +2 oxidation state in their oxides and oxygen and sulphur change from zero oxidation state to - 2 oxidation state. Change over from zero to +2 state can take place with loss of electron and zero to -2 state with gain of electrons. Loss of electron is defined as oxidation and gain of electron as reduction. Changes (vii) to (x) in all these reactions, there is no change in the oxidation state or valence of the reacting ions and are therefore known as non-redox reactions.

However, special names as synthesis, decomposition, displacement (substitution) double displacement, neutralisation etc. have been used. Thus reactions (i) to (iv) are synthesis reactions in which two or more elements combine to form a compound; reactions (v) and (vi) are displacement reactions where an element (or an ion) displaces another element or ion from its compounds; reactions (vii) to (x) are double displacement reactions in which two compounds interchange their partners to form two new compounds. Reaction X, however is better known as a neutralisation reaction. Reactions as decomposition of lead nitrate $Pb(NO_3)_2 \xrightarrow{heat} PbO + 2NO_2 + \frac{1}{2} O_2$ or electrolysis of fused salts by passing electric current $NaCl\ (fused) \longrightarrow Na(S) + \frac{1}{2} Cl_2\ (g)$ are redox reactions but better known as decomposition reactions.

Note:- 1) In the first case, it is $NO_3^- \longrightarrow NO_2 + \frac{1}{2} O_2$ where nitrogen from +5 oxidation state changes to +4 oxidation state in NO_2 and oxygen from -2 oxidation state goes to zero oxidation state.

2) Oxidation state is defined as the formal charge that appears to be on an atom in a covalent compound or a radical, taking oxygen as always -2 excepting peroxides and hydrogen as +1 (excepting hydrides). In an ionic compound it is the charge carried by the ions.

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HEAT CHANGES IN PHYSICAL AND CHEMICAL PROCESSES

Dr.S.K.Misra
Mr.Surendra Prasad

We know physical changes are those in which no new substance is formed and which can be easily reversed and chemical changes are those in which new substances are formed and can not be easily reversed. For instance ice, water wax can be liquified on heating and obtained back on cooling. Solution of sugar, salt can be prepared by stirring the sugar or salt in water and the solution can be evaporated to get back the salt and sugar. But on the otherhand reaction between a metal as zinc or magnesium with hydrochloric acid produces zinc choloride/magnesium chloride and hydrogen but the reaction can not reversed. Reaction between an acid and a base produces salt andwater and the reaction is irreversible. Candle, kerosene, petrol burn to produce CO_2 and H_2O and the reverse processes are unknown. Thus we distinguish physical changes from chemical changes by the facts that (1) whether new substances are formed or not ? (2) Whether the change is reversible or not ?

IDENTIFICATION OF PROBLEM:

Is there any other way of distinguishing physical changes from chemical changes ?

GATHERING OF FACTS:

- When ice melts or water vapourises heat is absorbed (heating, is required).
- When water is added to lime heat is evolved.
- When solid NaOH pallets are added to water heat is evolved.
- When glucose, NH_4Cl, KNO_3 are added to water heat is absorbed (the test tube gets cold).
- When a few drops of Conc H_2SO_4 is added to water heat is evolved (the test tube is hot to touch).
- When an acid is added to an alkali heat is evolved.
- When zinc/magnesium is added to dil Hcl, heat is evolved.
- All the above reactions take place spontaneously.

EXPERIMENT:
(TEACHER SUGGESTED ACTIVITY)

MEASUREMENT OF HEAT EVOLVED IN PHYSICAL AND CHEMICAL CHANGES

Weigh an empty thermocol glass with its cover (used for drinking coffee) or a calorimeter if available (W_1gms). Fill the glass with 100 cc of water and weigh it again (W_2gms). Insert a glass rod and a thermometer through the cover. Stir water gently with the glass rod note the temperature of water (t^o_1 C). Add about 2 grams of solid NaOH to the nearest 0.01 gram (5 to 6 NaOH pallets quickly weighed) and stir again. Note the highest temperature attained (t^o_2 C).

Heat gained by water = $(W_2-W_1) \times 1 \times (t_2-t_1)$ = heat evolved by the process assuming heat gained by the beaker is negligible (as we are not measuring absolute values but relative values for comparision).

(2) Repeat the experiment with NH_4Cl or KNO_3

Heat lost by water = $(W_2 - W_1) \times 1 \times (t_2-t_1)$

(3) Repeat the experiment with NaOH added to 100ml of 0.5 M HCl.

(4) Repeat the experiment with 1 gram of magnesium and 100ml of 0.5 M HCl. Calculate the amount of heat in terms of Cals/mole. What do we find ?

Heat given out or absorbed in physical changes is much smaller (a few calories compared to tens to hundreds of K Cals) compared to heat given out or absorbed in chemical reactions.

WONDERING WHY?

Why chemical changes are accompanied by larger heat changes compared to physical changes. In physical changes as phase changes, the bonds between atoms in molecules in different states remain in tact, only weak Van der wals forces are disturbed and small amounts of energy are needed to overcome these attractive forces. Thus the amount of heat absorbed to melt 18 grams of ice at $0^{o}C$ to water is only 1.438 Kcals and 18 grams of water to vapourise at $100^{o}C$ is only 9.717 KCals. Further, the inherent tendency of systems to become disordered favours change of state from solid to liquid and liquid to vapour. Reverse processes are favoured by the tendency to attain lower energy states.

The heat changes in dissolution processes arise from the energy needed to overcome the attractive forces in order to separate the molecules or ions constituting the solute (as sugar, salt); (2) the energy needed to separate the molecules of solvent sufficiently to introduce the solute particles (3) the energy released by interaction between solute and solvent molecules. The relative magnitudes of these processes vary from solute to solute and from solvent to solvent. The net heat released or absorbed is the sum of the energy changes and is known as heat of solution. This heat of solution of HCl per mole is -17.70 Kcals, heat of solution of

$NaCl$ is - 0.93 Kcals/m heat of solution of NH_4Cl is + 3.5 Kcals/mole.

On the other hand when a chemical change takes place, a large number of old bonds are to be broken and number of new bonds are to be formed and usually the energy changes in breaking and making of bonds involved are widely different resulting in large net heat changes. Thus the simple reaction between hydrogen and chlorine in which a mole of hydrogen bonds and a mole of chlorine bonds are to be broken and 2 moles of hydrogen chlorine bonds are to be formed, about 44 Kcals of energy is released. Similarly about 68 Kcals of energy is released when one mole of water is formed from its elements.

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LAW OF DEFINITE PROPORTIONS

Sri Razabin Khan
Dr.Pravin Kumar

We . define chemical change as those in which new products are formed.

IDENTIFYING A PROBLEM:

Is there any relationship between the amounts of reactants combining with each other and the amounts of products formed? Do reactants combine in any definite weight ratio ?

DESIGNING AN EXPERIMENT. TO FIND OUT:

Prepare 0.10 M KI and 0.1M Pb $(NO_3)_2$ solution.Take a set of five test-tubes and mark them (I,II,III, IV, V) and place them in order in a test-tube stand. Add carefully solution of KI, Pb $(NO_3)_2$ and water as shown in the table below using burettes.

Test tube	I	II	III	IV	V
$Pb(NO_3)_2$ Soln(0.1M)	9	9	9	9	9
KI Soln (0.1M)	3.	4.5	9	18	27
Water	28	26.5	2 2	13	4
Total:-	40	40	40	40	40

In a 250ml beaker take about 150 ml of water, place it on a tripod stand and warm it to almost boiling, place the test-tubes with the reactants in the beakers. Keep on warming the water bath intermittantly so as to maintain it at 70-80°C for about 20 min. Then remove the test tubes, allow them to cool at room temperature till the ppt settles down and the supernatant liquid becomes clear (Centrifuge tubes would be ideal if a centrifuge (hand operated) is available for carrying out the experiment).

Using a clean, washed dropping tube take out five drops of the supernatant liquid from test-tube I and put 2 drops each in two separate test-tubes. To the first test tube aid 2 drops of KI and to the second test tube and 2 drops of Pb $(NO_3)_2$ record your observation as to Which test tube gives a precipitate.

Repeat this second.part of the experiment with all the rest four test tubes and record your observation.

Test tube No.	ppt with KI	ppt with Pb $(NO_3)_2$
I	ppt	No ppt
II	ppt	No ppt
III	ppt	No ppt
IV	no ppt	No ppt
V	no ppt	ppt

OBSERVATION AND INFERENCE:

Test tube I, II, III ———— $Pb(NO_3)_2$ in excess

Test tube IV ———— neither all excess

Test tube V ———— KI in excess

Hence 9ml of 0.1M $Pb(NO_3)_2$ solution completely reacts with 18ml of 0.1M KI solution. Therefore 0.9×10^{-3} moles of $Pb(NO_3)_2$ combines with 1.8×10^{-3} moles of KI completely or 1 mole of $Pb(NO_3)_2$ reactive with 2 moles of KI (0.1 molar means, 1000ml of the solution contains 1 mole of the substance) and the product is PbI_2.

The precipitates formed in the test tubes can be filtered of using whatman 41 filter paper (previously weighed), washed with cold water 2-3 times, and finally with small amounts of alcohol, dried and weighed to prove that the amount of PbI_2 formed also bear a simple mole ratio with reactants. (Weight of PbI_2/molecular wt. of PbI_2 = no. of moles of PbI_2).

GENERALISATION:

The reactants and products of a reaction bear a simple mole ratio to each other.

ACTIVITY-2

Since generalisation can not be made with only one experiment, the following activity may be considered.

Take a clean dry china clay basin, weigh it accurately (W_1 gms). Take a few pieces of clean copper turnings in the basin and weigh again (W_2 grams). Now dissolve the copper turnings by adding concentrated nitric acid drop by drop. When all the copper turnings are dissolved carefully evaporate the green solution formed (preferably in a fume cupboard or near a window) till all the brown fumes are removed and a black ppt is left behind. Allow the basin to cool and weight again (W_3 gms). The black precipitate is CuO. $Cu(NO_3)_2 \longrightarrow CuO + 2NO_2 + \frac{1}{2}O_2$)

Weight of copper turnings = (W_2-W_1) gm

Weight of copper oxide formed = (W_3-W_1) gm

Weight of oxygen which has combined with copper = $(W_3 - W_2)$ gm

No.of moles of copper atom = $\frac{(W_2-W_1)}{\text{at. wt. of copper}}$

No.of moles of oxygen atom = $\frac{W_3-W_2}{16}$

No.of moles of CuO molecules formed

$$= \frac{W_3 - W_1}{\text{molecular weight of CuO}}.$$

What is the mole ratio of copper to oxygen to copper oxide formed ?

QUESTION TO WONDER ABOUT:

Why reactants and products of a reaction bear simple ratio to each other ? (Discussion can be made on the basis of Dalton's atomic theory).

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SLOW COMBUSTION RUSTING AND CORROSION

Dr.J.N.Dash

OBSERVATION:

Iron nails, clips, pins, articles as window grills get coated with a brownish material on being exposed to the atmosphere for few days.

- Copper articles get blackened or get coated with a green material.
- Most metals loose their shine (Lusture) on being exposed to the atmosphere.

PROBLEM:

- What is the brown material which can be scrapped of from iron nails?
- What is the cause of loss of lusture with most metals on being exposed to the atmosphere ?

GATHERING OF FACTS:

- The air (consists of oxygen, nitrogen, small amounts of carbon dioxide and water vapour.
- Nitrogen is highly unreactive does not combine readily with other substances.
- Carbondioxide also does not combine with other substances under ordinary atmospheric conditions.
- Pure iron does not rust.

HYPOTHESIS:

Most metals probably can combine with oxygen to form oxides which is accelerated by the presence of impurities and moisture.

EXPERIMENT DESIGNED TO VERIFY THE HYPOTHESIS

- A small portion of the brown material scrapped off from nails, is taken in a clean dry test-tube and heated over a flame. Water particles were observed in the cooler parts of the test-tube.
- Another small portion of the brown material is dissolved in hot dilute Hcl and divided into two parts.
- To part (1) few drops of KCNS solution was added and to part II a few drops of $K_4Fe(CN)_6$ are added.
- Known salt solutions of Fe(III) and Fe (II) are prepared and each divided into two parts. To part I, a few drops of KCNS and to part II $K_4Fe (CW)_6$ were added as before and compared with the solution of brown material.
- To another portion of the brown material taken in a test-tube a pinch of MnO_2 is added and heated. The gas evolved is tested for oxygen.

- MnO_2 taken alone in another test tube is heated to see if any oxygen is evolved or not?

CONCLUSION:

The brown material is Fe_2O_3, x H_2O or Fe (OH)$_3$. The formation of the hydrated oxide can be explained assuming iron getting oxidised in presence of moisture.

$$Fe + O_2 + H_2O \dashrightarrow {}_2O_3, \; x\, H_2O$$

FURTHER ACTIVITY TO SHOW OXYGEN AND WATER ARE NECESSARY FOR RUSTING TO TAKE PLACE:

- Take a set of three test-tubes. In one of the test tubes take a small amount of fused calcium chloride. Cover it with cotton. Place a few iron nails on the cotton and close the mouth with a cork and seal with wax.
- Fill another test-tube to half its volume with water, boil to expel air above it and any dissolved oxygen. Put 3-4 iron nails and close the mouth again with a cork and seal it with wax.
- In the third test-tube take a few cc of water, put 3-4 iron nails and again close the mouth with a cork.

- Allow the test-tubes to stand for a week and observe in which test tube the nails have been coated with the brown material the most and the least.

FOLLOW UP DISCUSSION:

The brown material, known as rust, is formed by oxidation of iron in such a slow process that no measurable amount of heat is liberated. It is therefore known as slow combustion.

The rust is formed only when iron has copper or tin as an impurity. In presence of water iron behaves as anode and the impurity behaves as cathode and water functions as an electrolyte. Thus an electrochemical Cell sets up and the reaction taking place.

at anode $Fe \longrightarrow Fe^{+2} + 2e$

at cathode $\frac{1}{2} O_2 + H_2O + 2 e^- \longrightarrow 2 OH^-$

$$Fe + \frac{1}{2} O_2 + H_2O \text{ ——— } Fe(OH)_2$$

$Fe(OH)_2$ is further oxidised to $Fe_2O_3 \times H_2O$, Moisture serves as the medium through which ions travel to complete the circuit.

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FUELS AND COMBUSTION

Sri Brindaban Panda
Sri Prasan Kumar Mis

We use wood, coalgas (LPG) to cook . food and keep houses warm in winter. We use Kerosene to light lamps when there is power-cut or burn candles (wax). We use petrol, diesel to run cars, scooters, coal to run trains (or electricity), air crafts (aviation petrol), Kerosene for jet planes run tractors, pumps for lifting water for irrigation with petrol or diesel. We use coal, coke, water gas producer gas in . industries. Thus we use a variety of substances as sources of energy to meet our needs. We get energy by burning them in air or oxygen.

QUESTION TO WONDER ABOUT:

Many other substances as paper, straw, spirit, sulphur, camphor, cowdung also burn to produce heat and light. Why we do not use these for meeting our energy needs? Why do we use kerosene for lighting lamps and in stoves for cooking food not petrol ? Let us find out.

TEACHER'S DEMONSTRATION:

The teacher collects as many of the above mentioned substances as possible. Takes a small amount of each on a copper foil, folded into a cup, and heat over a flame.

The students are asked to observe.

(a) Which produces more light ?

(b) Which produces more smoke ?

(c) Which produces more ash ?

(d) Which catch as fire immediately and which catch as fire after sometime.

(e) Which produces more heat ?

(f) Which are readily available and cheap ?

TEACHER'S SUGGESTED ACTIVITY:

(How do we know which produces more heat ?)

Amount of heat given out can be compared by burning a known amount of the fuel in a suitable manner so as to minimise all losses and measuring the rise in temperature of a definite volume of water. It can be expressed in terms of Cals/gm or the Cals/mole. A procedure for comparing heat produced by methyl alcohol or spirit, benzene and petrol, given in this report (Calorific values of liquid fuels). One can compare the amounts of heat given out per mole of methyl alcohol, benzene, n-hexane as pure compounds (kerosene, diesel, petrol are mixtures of hydrocarbons whose molecular weights depend upon composition).

OBSERVATION:

Substances as wax, sulphur, camphor, produce more smoke, more light, less heat, do not catch fire immediately.

Substances as paper, straw etc. produce ash, less heat more light, catch fire immediately. Substance as coal gas, natural gas, LPG catch fire immediately and produce little smoke and large amounts of heat.

Substances as kerosene, diesel, produce no ash, more smoke less heat burn slowly, but can be made to produce as much heat as petrol, when allowed to burn completely (in stoves, when we put the perforated mesh around the wicks).

Petrol burns with less smoke, no ash, and more heat, burns rapidly. Wood and coal catch fire with difficulty but when broken to chips catch fire but once these start burning, lot of heat is produced lot of ash and smoke are produced.

CONCLUSION:

Different substances ignite and continue to burn without further addition of heat at different temperatures. This temperature is known as ignition temperature.

Coke, Petrol , diesel, coal gas and LPG are good fuels which produce less smoke, no ash, and large amounts of heat when burnt under controlled conditions in a furnace or an engine. Such substances are known as fuels and the process of burning is known as combustion.

ALL COMBUSTIBLE MATERIALS ARE NOT FUELS:

What are the products of combustion? Are they same with all the fuels ?

TEACHER'S DEMONSTRATION:

Set up an arrangement as shown in the diagram below. Light the candle, and suck in the products of combustion through fused $Cacl_2$ and lime water by means of a filter pump.

OBSERVATION:

Water is formed which is absorbed by fused $CaCl_2$

CO_2 is formed which turns lime water milky.

CONCLUSION:

CO_2 and water are the products of combustion with, may be, traces of other substances (as particulate matters and SO_2).

All fuels have carbon, hydrogen as the main constituents. Small amounts of oxygen, nitrogen, sulphur may be present which contribute little towards the amount of heat evolved, during combustion.

CALORIFIC VALUE OF LIQUID FUELS

Sri G.S.Bhimaraju

OBSERVATIONS:

A variety of fuels are being used for various purposes in our daily life. Some fuels are solids like coal, some are liquids like kerosene, petrol, diesel and some are gaseous fuels like natural gas, LPG gas, Kerosene is used as a fuel for stoves and jet aircraft engines; petrol is used as a motor fuel and diesel oil is used as a fuel for high speed diesel engines in trains and heavy vehicles.

IDENTIFICATION OF A PROBLEM:

Among the known and easily available liquid fuels viz. Petrol, Benzene and ethyl alcohol which is a better fuel ?

GATHERING INFORMATION:

- Fuels like kerosene, diesel oil and petrol are all made up of mixture of hydrocarbons (compounds containing carbon and hydrogen).
- Fuels on burning get oxidised to CO_2 and H_2O with the liberation of heat energy.
- The energy liberated by the burning of fuel is used for doing work.

- The fuel efficiency is expressed in terms of calorific value.
- Calorific value of a fuel is the quantity of heat produced by a given mass of the fuel on complete combustion (expressed in joules per Kg or calories per gm.).

HYPOTHESIS:

Since petrol is used widely as an aviation and motor fuel it probably has a higher calorific value .

DESIGNING EXPERIMENTS TO VERIFY THE HYPOTHESIS

Activity:

A spirit lamp filled with the fuel whose heat of combustion is to be determined is weighed. It is placed below a 250ml beaker containing say 100ml water. The lamp is lighted and allowed to burn till the rise in temperature of water is about 10°C. The lamp is again weighed to determine the mass of hydrocarbon fuel left over. This experiment is repeated with other fuels and in each case the amount of fuel in grams needed to raise the temperature of same 100ml water through 10°C is found out.

PRECAUTION:

1) Beaker is to be covered with a non-conducting material like cardboard with two holes; one for placing a stirrer and the other for placing a thermometer. A perforated wooden enclosure may be placed around the whole set up to prevent heat loss to the surroundings.

2) Determination of water equivalent: A known amount of cold water m_2 (say 50ml) is taken in a 250ml beaker and its temperature noted (t_1^o C). A known amount of water m_1 (say 50ml) is heated to 50°C in a 250ml beaker. Its temperature is noted ($t^o{}_2$ C) and it is quickly added to the cold water. The mixture is stirred and the resultant temperature noted ($t^o{}_3$). This data is used for calculating the water equivalent of the 250 ml beaker.

Heat lost by hot water = heat gained by 250 ml beaker + 50 ml cold water

$M_1(t_2-t_3) = (W + M_2)\ (t_3-t_1)$ where W is the water equivalent of the beaker.

$$\text{Hence } W = \frac{M_1\ (t_2 - t_3)}{t_2 - t_1} - M_2$$

The heat produced due to combustion is equal to heat gained by beaker and water.

Heat gained = $(W + m) \Delta t$

$= (W + 100) \times 10$ in calories

From this the amount of heat produced in calories by the combustion of one gram of each fuel is calculated.

OBSERVATION:

From the above activities it will be observed that petrol has a higher calorific value than ethyl alcohol and Benzene.

GENERALISATION:

Petrol has a higher calorific value (better fuel) compared to ethanol and benzene.

....

WHAT ARE ELECTRO-CHEMICAL CELLS AND HOW THEY FUNCTION ?

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OBSERVATION:

Dry cells (batteries) are used in transistors, watches, toys, hearing devices and even pace makers.

- Car batteries can be recharged ;
- a dead battery is often found to be coated with a sticky fluid (if not leak proof).

IDENTIFICATION OF A PROBLEM (Wandering Why)

- How does a dry cell produce current ?
- Why it can not be recharged ?
- Why does it become dead after being uses for sometime?

GATHERING OF INFORMATION:

- What are the components of a dry cell. (The teacher can open up a dead cell and show that it consists of a graphite rod at the center and a zinc container with some chemicals.
- ionic compounds in fused state or in solution allow electric current to flow through them and are good conductors (Electrolytes).

- Energy can not be created out of nothing nor can be destroyed.
- one form of energy can be converted into another form of energy;
- energy is released or absorbed (in the form of heat) when substances react with each other (a chemical change takes place).

HYPOTHESIS:

"Probably electrical energy is produced due to some chemical reaction taking place when graphite rod and the zinc container and the electrilyte are in contact with each other.

DESIGNING AN EXPERIMENT TO TEST THE HYPOTHESIS:

In a 250 ml beaker, about 100 ml of dilute sulphuric acid (an electrolyte) is taken. A graphite rod and a Zinc plate is immersed in the acid solution (to make contact between the three). The graphite rod and the zinc plate are connected to a Milli ammeter or a galvanometer with a resistance in parallel as shown in the diagram to detect the current, if produced.

It will be observed

- there is a flow of current, the deflection of the pointer in the galvanometer is to the right;
- no heat is produced in the beaker but when the reaction between zinc and H_2SO_4 is carried out in test tube, heat is produced;
- bubbles on the surface of the carbon electrode (Zinc is known to react with dil H_2SO_4 and hydrogen is liberated).
- The zinc plate is gradually being eaten away by the acid (presence of zinc ions in solution can be proved by passing H_2S).

CONCLUSION:

Zinc atoms leave the surface of the zinc electrode and go into solution as Zinc ions.

$$Zn \dashrightarrow Zn^{++} + 2e \text{ (Oxidation)}$$

$$Zn^{++} + SO_4^{=} \dashrightarrow Zn\ SO_4^{=}$$

- hydrogen ions in the solution are reduced to hydrogen at the surface of the graphite electrode.

$$2H^+ + 2e \dashrightarrow H_2 \text{ (reduction)}$$

The net reaction in the arrangement

$$Zn + 2H^+ \dashrightarrow ZnSO_4 + H_2$$

- The energy change for the net reaction in the arrangement appears, as electrical energy as it can not appear as heat in this cases.

(The teacher at this stage may state that such a device was first constructed by Allsandro Volta in 1796 and such devices are known after him as Voltaic cells. The graphite rod and the zinc plate are termed as electrodes).

FURTHER INVESTIGATION:

If the combination of graphite rod, zinc and dil H_2SO_4 can produce electrical energy, it should be possible to get electric energy from other combinations of electrodes and electrolytes to support our conclusion.

EXPERIMENTS

Collect rod or plates of different metals (as Cu, Al, Ag, Sn, Nickel) and prepare 1M solutions of $ZnSO_4$, $CuSO_4$, $AgNO_3$ NaCl, dil HCl, NH_4Cl). Take any two different metals connected with connecting wires, dip them in one of the above solutions record your observations. Wash the electrodes with water. Dip them in another solution record your observation. In this way try all solutions and all combinations record your observations.

Solutions	Zn-Cu	Cu-Ag	Zn-Ag	Al-Cu	Al - C	Remarks
$ZnSO_4$						
$CuSO_4$						
$AgNO_3$						
NaCl						
dil HCl						
NH_3						

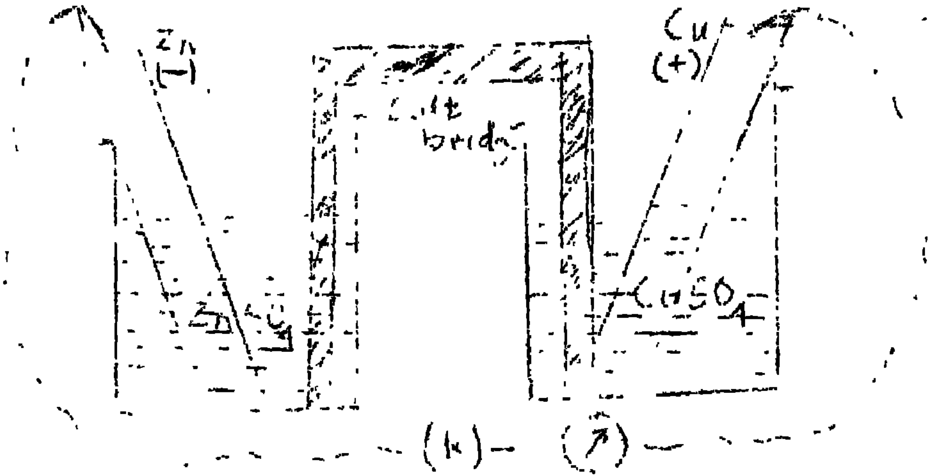
(In most of these combination appreciable voltage or current may not be observed and further rapid fall in the voltage or discharge occurs. However, some of them would show definite voltage momentavily.

GENERALISATION:

Two different metal strips dipped in suitable electrolytes produce electric current.

TEACHER'S SUGGESTED ACTIVITY: (Construction of Danial cell which gives a steady voltage).

Take two 100ml beakers. In one take Zn SO_4 solution (1M) and in the other $CuSO_4$ solution (1M). Place a strip of Zn plate in $ZnSO_4$ solution and a copper strip in $CuSO_4$ solution. Connect the two solutions by means of a salt bridge (A salt bridge can be prepared by allowing a solution of NH_4NO_3 (7.5g) in agar-agar (2gm) with 25ml of water), a strip of filter paper soaked on KNO_3 solution can be used in place of salt bridge. Now connect the two electrodes with connecting wires to a volt meter as shown in the diagram.



Zinc with $ZnSO_4$ solution is called one half cell and copper with copper sulphate solution in the other half cell. The two half cells constitute a complete cell, known as Daniel Cell.

OBSERVATIONS:

- There is a flow of current.
- In the zinc half cell, zinc goes into solution (loss in weight of the zinc electrode).
- In the copper half cell, copper gets deposited, the blue colour slowly fades and finally becomes colourless.

CONCLUSION:

There is a chemical change. In the left half cell zinc is oxidised to zinc ions ($Zn \rightarrow Zn^{++} + 2e$) and in the right half cell copper ions get reduced ($CU^{++} + 2e \longrightarrow Cu^{0}$) .. The net reaction is

$$Zn + Cu^{++} \longrightarrow Zn^{++} + Cu$$

(The zinc ions formed combines with sulphate ion in the solution, sulphate ions migrate through the bridge from right half cell to the left, some Zn^{++} ions, migrate in the opposite direction. Flow of ions, across the bridge prevents accumulation of (+)charge in the left beaker and (-)ve charge in the right beaker which otherwise would stop flow of current).

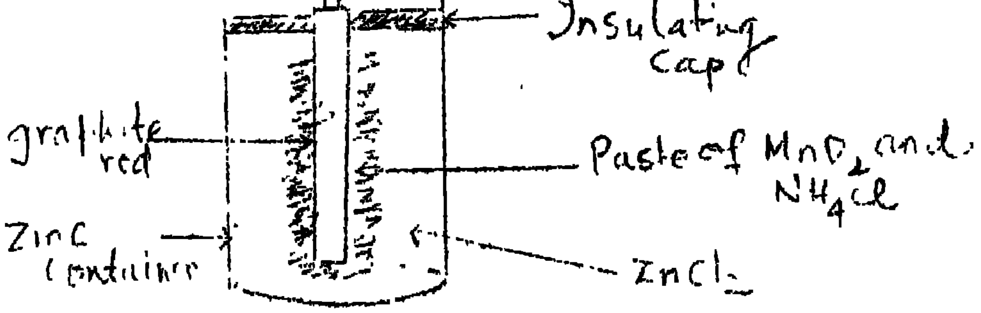
FURTHER ACTIVITIES:

- Construct a number of half cells $Zn/ZnSO_4$, $Cu/CuSO_4$, $Ag/AgNO_3$, $Al/Al(NO_3)$, $Ni/NiSO_4$, $Fe/Fe\ SO_4$.
- Combine any two half cells, measure the voltage (EMF) and note the direction of flow of current using a galvanometer as before.
- Discuss why current flows in ~~the~~ one direction or other.

- Explain the activity series.
- What will happen if a zinc plate is placed in copper sulphate solution, a copper plate is placed in zinc sulphate solution, if a copper plate is placed in Ag NO_3 solution and a silver wire is placed in copper nitrate solution? Can electron transfer take place from the metal plate to the solution in contact?
- Is there any weight relationship between the loss in weight of copper plate and the gain in weight of the silver electrode in the cell $Cu/CuSO_4 \,||\, Ag\,NO_3/Ag$?

FOLLOW UP DISCUSSIONS:

A dry cell consists of a zinc container which serves as the anode or negative termed and a graphite electrode which serves as the cathode or the +ve terminal. The graphite rod is covered with powdered MnO_2 and a paste of NH_4Cl and $ZnCl_2$ as shown in the diagram.



The reaction of the anode

$$Zn \longrightarrow Zn^{++} + Ze$$

The reaction at the cathode

$$MnO_2 + 2NH_4^+ \longrightarrow MnO + H_2O + 2\ NH_3$$

net reaction

$$Zn + MnO_2 + NH_4Cl \longrightarrow MnO + ZnCl_2 + H_2O + 2\ NH_3$$

$$NH_3 + Zn\ Cl_2 \longrightarrow Zn\ (WH_3)_2\ Cl_2$$

(Secondary reaction)

$$Zn^{++} + 2\ OH^- \longrightarrow ZnO + H_2O$$

(Secondary reaction)

These secondary reactions are irreversible and do not allow recharging.

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ELECTROLYSIS AND ITS APPLICATION

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OBSERVATION:

All reactions appear to proceed in one direction only at a given temperature and pressure. e.g. (1) Sodium burns in Cl_2 gas to form sodium chloride (2) Magnesium burns in oxygen to produce magnesium oxide and fuels burns in oxygen to produce CO_2 and H_2O. (3) Glucose in our body burns producing CO_2 and H_2O.

IDENTIFICATION OF A PROBLEM(Wondering why)

Why do the reactions proceed in one direction only? How does the system know the direction in which it has to change ? Can the reactions be made to take place in opposite direction?

GATHERING OF INFORMATION:

- plants synthesise glucose from carbon dioxide and water;
- storage batteries can be recharged by electric current;
- water can be pumped from lower level to higher level;

- all these reactions/changes occur when energy is spent or work is done on the system (Work is a form of energy).

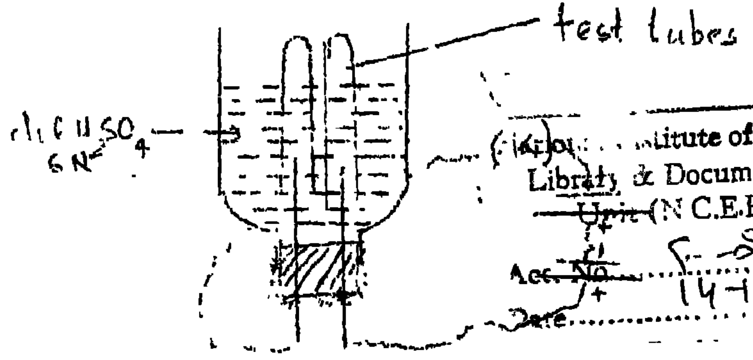
HYPOTHESIS:

.Some nonspontaneous reactions can be reversed by supplying energy from external source and some others by changing experimental conditions.

DESIGNING EXPERIMENTS TO VERIFY THE HYPOTHESIS:

Activity-1: (Electrolysis of water)

Take a narrow mouth plastic bottle, remove its bottom. Fix a rubber cork at the mouth. Insert two pieces of nichrome/jem clip wire into the rubber cork. Seal the gaps, if any, between the plastic bottle and the rubber stopper with molten wax. Fix the bottle assembly to the clamp asshown below. Half fill the bottle with water. Add a few c.c of 6N H_2SO_4 or fill the bottle with 1.0N NaOH solution. Invert two test tubes filled with 2N H_2SO_4/1N KOH ever the electrodes. Connect the ends of the wire to a D.C. source or to 2 dry cells connected in series.



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OBSERVATION:

Gases are evolved at the electrodes which collect in the test-tubes by displacement of of solution. The gas collecting in the test-tube inverted over the wire connected to the negative terminal of the battery is hydrogen (which explodes with a pop sound on bringing a lighted match stick near the mouth of the test tube). The gas collecting at the other electrode which is connected to the positive terminal of the battery is oxygen (which supports combustion - a burning match stick burns more brightly).

CONCLUSION:

Water is decomposed to hydrogen and oxygen when electrical energy is spent.

REACTIONS AT THE ELECTRODES:

When dil H_2SO_4 is used, the reaction at the (-) ve terminal (Cathode) $2H^{+} + 2e^{-} \longrightarrow H_2(g)$

at the + ve terminal (Anode) is

$$H_2O \longrightarrow 2H^{+} + 1/2\ O_2 + 2e^{-}$$

net reaction $H_2O \longrightarrow H_2 + \frac{1}{2} O_2$

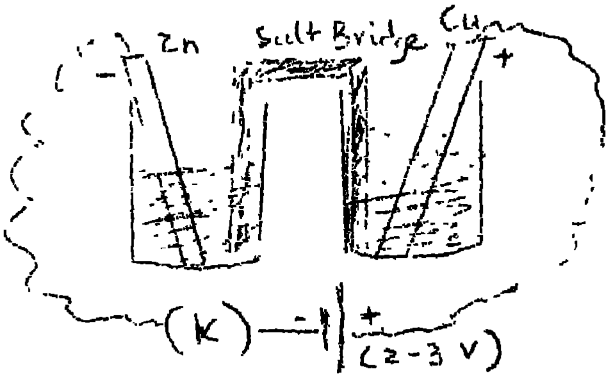
when KOH is used, the reaction at cathode

$$2H_2O + 2e^{-} \longrightarrow H_2 + 2OH^{-}$$

at anode $2OH^{-} \longrightarrow \frac{1}{2} O_2 + H_2O + 2e^{-}$

net reaction is $H_2O \longrightarrow H_2 + \frac{1}{2} O_2$

Activity-2: Set up the daniel cell as shown below



Connect the zinc electrode to the negative terminal and the copper electrode to the + ve terminal of the cell to a D.C. source (2-3v), preferably a battery eleminator and allow electric current to pass through for sometime. Voltage of the external supply should be greater than the emf of the Daniel cell .

OBSERVATION:

Deposition of zinc on zinc electrode (gain in weight of the electrode and fall in concentration of zinc ions in solution). (2) Copper dissolves from the copper electrode (colour of the solution intensifies and loss in weight of the electrode).

CONCLUSION:

The reaction taking place at the zinc electrode is $Zn^{++} + 2e \longrightarrow Zn$ and at the copper electrode is $Cu \longrightarrow Cu^{++} + 2e$. The net reaction is $Zn^{++} + Cu \longrightarrow Cu^{++} + Zn$ which is reverse of the reaction taking place in the Daniel cell.

Activity-3:

Take a 250ml beaker, half filled with a solution of copper chloride (1N) or copper sulphate solution (1N) acidified with sulphuric acid, Collect a graphite electrode from an old battery and a metal plate (or spoon) to be coated with copper. Place them in the beaker, connect the graphite electrode to the positive and the metal plate (spoon) to the negative terminal of the battery (D.C. source) and allow electric current to flow.

OBSERVATION:

The metal spoon is found to be coated with copper. Chlorine is found to be liberated at the carbon electrode, net reaction being

$$Cu\,Cl_2 \longrightarrow Cu + Cl_2$$

when $CuCl_2$ solution is used.

GENERALISATION:

Many reaction can be reversed by spending electrical energy which do not occur spontaneously.

FOLLOW UP DISCUSSION:

Decomposition of H_2O, $CuCl_2$ solution, alkali and alkaline earth halides in fused state, by passing electric current through them is known as electrolysis and the device (set up for carrying out decomposition are known as electrolytic cells). In all these processes, electrical energy is converted into chemical energy. (a non-spontaneous chemical change is brought about). This finding has led to very important industrial applications such as (a) extraction of alkali and alkaline earth metals (b) purification of metals, (c) electroplating of metals for protection from corrosion.

Storage battery(Pb- accumulator) consists of a series of parallel lead electrode and a set of parallel lead dioxide electrodes interposed between the first set placed in a tank filled with dilute sulphuric acid. When current is supplied by the cell, the cell reaction is

$Pb(s) \longrightarrow Pb^{++} + 2e^{-}$ (anode)

$Pb^{++} + SO_4^{=} \longrightarrow Pb\ SO_4(S)$

$Pb\ O_2 + 4H^{+} + 2e^{-} \longrightarrow Pb + 2H_2O$ (Cathode)

$Pb^{++} + SO_4^{=} \longrightarrow Pb\ SO_4(S)$

$Pb + Pb\ O_2 + 2H_2SO_4 \longrightarrow 2Pb\ SO_4(S) + 2H_2O$

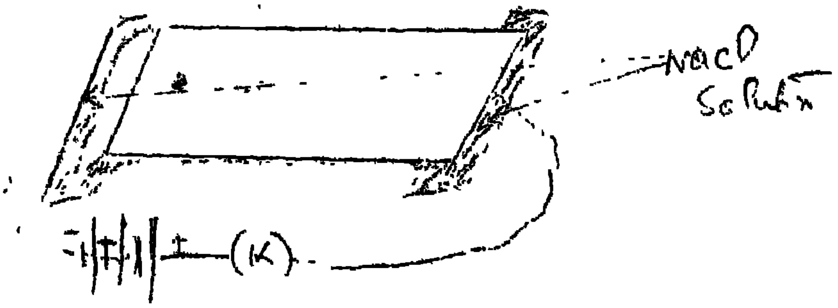
When the surface of all plates becomes coated with lead sulphate, they behave chemically alike and current flow ceases. To recharge a storage cell, the two terminals are connected to a D.C. source in such a way that the reaction is reversed.

$$2\ Pb\ SO_4(S) + 2H_2O \longrightarrow Pb + Pb\ O_2 + 2H_2SO_4$$

FURTHER INVESTIGATION:

In an electrolytic cell, it is the oppositely charged ions which carry the current (the migration of the ions constitute current). How do we prove that ions are migrating in an electrical field ? What is the role of the external emf ?

Activity-4: (to show migration of ions)



Take a 3 x 8 Cm^2 size filter paper strip. Moisten it with a 10% solution of NaCl. Put the strip on a glass plate. Connect the ends of the filter paper with a D.C. source of 9-12 volts with crocodyle clips. Now make a $K_2\ Cr_2O_7$ spot near the negative terminal, (keep the filter paper wet during the experiment in the 10% NaCl solution ?) What happens to the dichromate spot? What is your conclusion ?

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CLASSIFICATION OF ORGANIC COMPOUNDS

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Some millions of organic compounds are known till to-day. How to classify these compounds into a few groups? This can be achieved by the study of their properties. Solubility behaviour is one such property which may help in classifying these compounds.

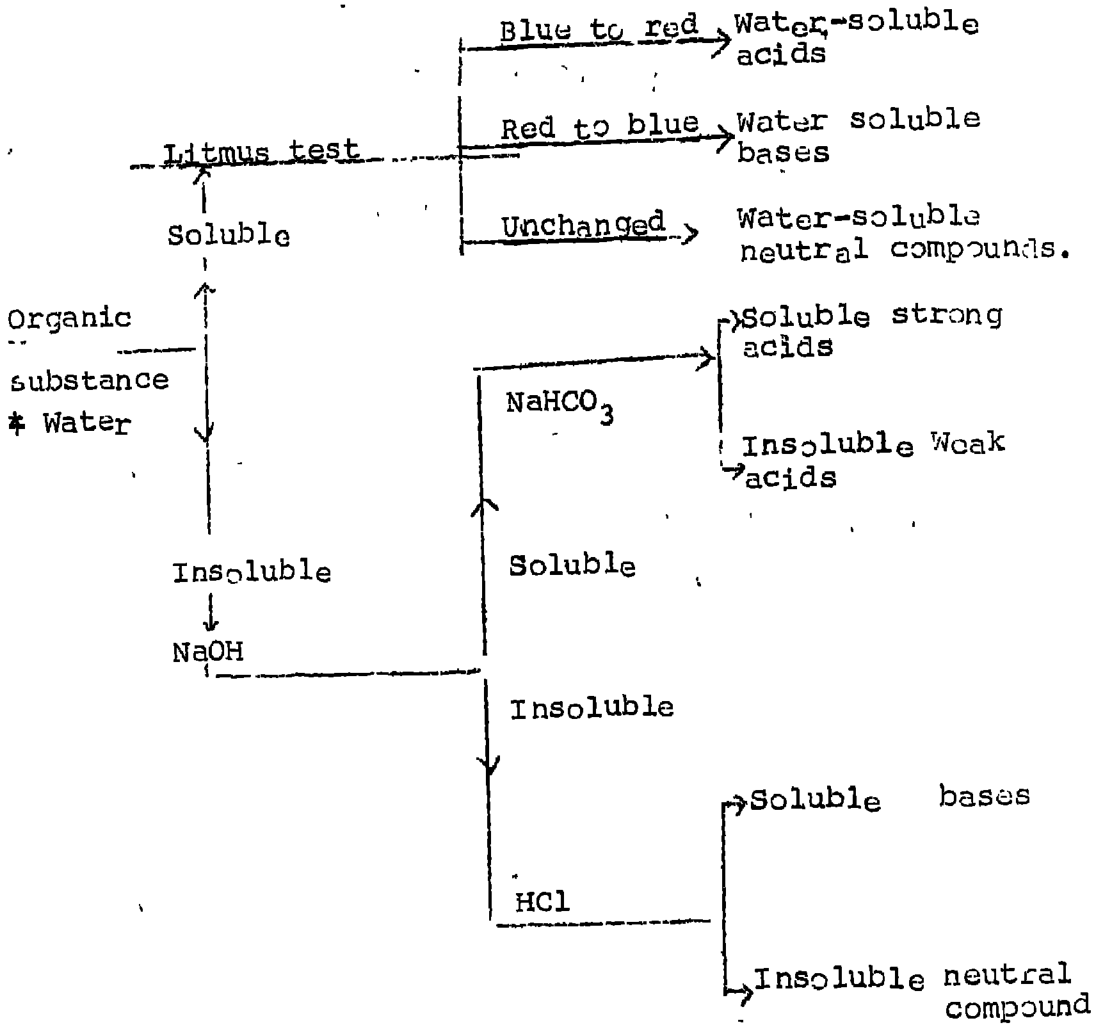
Solvents which can be used for the study of solubility behaviour: NaOH, $NaHCO_3$, HCl (all aqueous 5% solutions) and H_2O (polar solvents). Organic compounds for the study:

1) Oxalic acid, 2) Acetic acid, 3) Methylamine, 4) Urea, 5) Sugar, 6) Acetone, 7) Ethyl alcohol, 8) Benzoic acid, 9) Phenol, 10) Aniline, 11) Benzene, 12) Toluene.

Activity-1:

Summary of the solubility test procedure is given in scheme 1. After testing the solubility of the original substance in a solvent, a clean test-tube with fresh original substance must be used for the next solvent.

Scheme-I



POSSIBLE OBSERVATIONS:

(i) Oxalic acid and acetic acid are water soluble and their solutions turn blue litmus red - so they are water soluble acids.

(ii) Methylamine is soluble in water and the solution turns red litmus blue: water-soluble base.

(iii) Urea, sugar, acetone and ethyl alcohol are all water soluble and their aqueous solutions have no action on litmus: Water soluble neutral compounds.

(iv) Benzoic acid is soluble to NaOH and also in $NaHCO_3$: strongly acidic.

(v) Phenol is soluble in NaOH but insoluble in $NaHCO_3$: weakly acidic.

(vi) aniline is insoluble in HaOH and soluble in HCl : a base.

(vii) Benzene and toluene are insoluble in H_2O, HaOH as well as HCl : Neutral compounds.

WONDERING WHY:

a) Why Oxalic acid and acetic acid are soluble in water ?

b) Benzoic acid although an acid is insoluble in water but soluble in NaOH/$NaHCO_3$ Why ?

c) Why methyl amine is soluble in water ?

d) Why Urea, sugar, acetone and ethyl alcohol are all soluble in water ?

e) Benzoic acid is soluble in $NaHCO_3$ but not in Phenol. Why ?

f) Why phenol and benzoic acid are soluble in NaOH ?

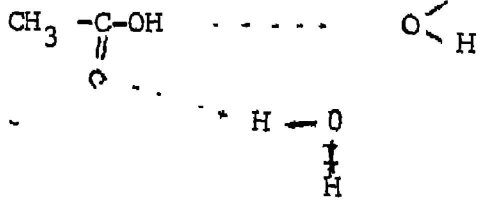
g) Why aniline is soluble in HCl ?

h) Why benzene and toluene are insoluble in all the solvents tried ?

POSSIBLE EXPLANATIONS:

a) Oxalic acid and acetic acid have carboxylic acid functional group viz. COOH. This group being polar can ionise in water or it can form hydrogen bonds with water.

e.g. $CH_3COOH + H_2O \longrightarrow CH_3COO^- + H_3O^+$ or



b) Benzoic acid (C_6H_5COOH) has a benzene ring containing 6 carbons. Due to the non-polar nature/hydrocarbon nature of the ring, hydrocarbon (water-repelling) character predominates. But benzoic acid is soluble in NaOH and $NaHCO_3$ due to the formation of soluble ionic compound i.e. sodium benzoate.

$C_6H_5CO_2H + NaOH \longrightarrow C_6H_5COO^- Na^+ + N_2O$

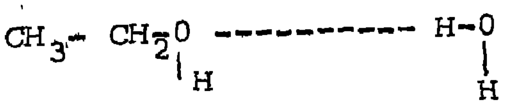
Stronger acid — Water-soluble Weaker acid

$C_6H_5CO_2H + NaHCO_3 \longrightarrow C_6H_5COO^- Na^+ + CO_2 + H_2O$

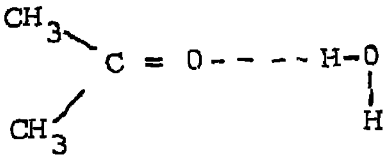
c) Methylamine (CH_3NH_2) has a dominating polar group - NH_2 and it can form water soluble ionic species with water.

$$CH_3NH_2 + H_2O \qquad CH_3\,NH_3^+ + OH^-$$

d) Urea ($H_2N-CO-NH_2$), sugar (a disachharide of glucose and fructose) acetone (CH_3COCH_3) and ethyl alcohol (CH_3CH_2OH) have highly polar groups and they are soluble in water due to hydrogen bonding with water molecules 2.g.



$$CH_3-CH_2\underset{|}{O}\text{-----------}\underset{|}{H-O}$$



e) Benzoic acid is soluble in $NaHCO_3$ due to the formation of sodium salt.

$$C_6H_5COOH + HCO_3^- \text{ ----- } C_6H_5COO^- + H_2CO_3$$

Strong acid Weak acid

Benzoic acid being a stronger acid than carbonic acid, equilibrium lies towards right

$$C_6H_5OH + HCO_3^- \text{ ------ } C_6H_5O^- + H_2CO_3$$

Weak acid Strong acid

But H_2CO_3 being a stronger acid than Phenol, equilibrium remains towards left so it is insoluble.

f) $C_6H_5OH + NaOH \longrightarrow C_6H_5O^- Na^+ + H_2O$

$C_6H_5CO_2H + NaOH \longrightarrow C_6H_5COO^- Na^+ + H_2O$

Stronger acids Weaker acids

Phenol and benzoic acid are soluble in NaOH because both are stronger acids than water and both of them form water soluble sodium salts.

g) Aniline is soluble in aq. HCl due to the formation of water soluble ionic salts.

$$C_6H_5NH_2 + HCl \longrightarrow C_6H_5N^+H_3 + Cl^-$$

h) Benzene and toluene have no polar groups and due to the hydrocarbon nature-they cannot form hydrogen bonds/ionic salts with the solvents.

HYPOTHESIS:

1) Organic compounds can be of three types viz. acidic, basic and neutral.

2) Polar compounds are soluble in polar solvents and non-polar/weakly polar compounds are insoluble in polar solvents.

TESTING THE HYPOTHESIS:

Activity-2:

Test the solubility of any organic compound available to you as per the scheme 1.

OBSERVATION:

You will find that it will be either acidic or basic or neutral in nature.

Activity-3:

Test the solubility of organic compounds containing (i) Polar groups like - COOH or -OH or $-NH_2$ or - CHO or $>C = 0$ etc. and a small hydrocarbon chain in the solvents mentioned as per scheme-1.

OBSERVATION:

You will find that whatever be the compound, the presence of a dominating polar group makes the compound soluble in polar solvents like water or NaOH aq. or $NaHCO_3$ (aq) or HCl (aq.).

Activity-4:

Test the solubility of non-polar compounds like hydrocarbons in the solvents as per scheme 2.

OBSERVATION:

You will find that whatever be the hydrocarbon used, it will be insoluble in any of the polar solvents used.

GENERALISATION:

1) Organic compounds can be classified into acidic, basic and neutral substances based on their solubility behaviour.

2) Polar organic compounds are soluble in polar solvents where as non-polar/weakly polar substances are insoluble in polar solvents.

CLASSIFICATION OF HYDROCARBONS

Mrs. Shanti Das

OBSERVATION:

There are thousands of known compounds composed of two elements carbon and hydrogen. These compounds e.g. methane CH_4, ethane C_2H_6, ethylene C_2H_4, acetylene C_2H_2 etc. are combustible and on burning they produce CO_2 and H_2O. But all hydrocarbons don't have the same general formula. That means they are structurally different.

IDENTIFICATION OF THE PROBLEM:

If all the hydrocarbons do not have similar structural feature - then, what chemical properties can be used to classify them ?

GATHERING OF INFORMATION:

- organic compounds differ in their reactivity due to differences in their structures.
- more reactive compounds can be easily oxidised with acidified/alkaline permanganate and they can also be easily brominated with molecular bromine.

HYPOTHESIS:

Hydrocarbons can be classified based on their reaction with cold alkaline/acidic $KMnO_4$ solution.

DESIGNING EXPERIMENTS TO VERIFY THE HYPOTHESIS:

Activity-1:

Take methane (prepared by the action of soda lime on sodium acetate) or kerosene, ethylene (Prepared by the action of conc. H_2SO_4 on ethyl alcohol) or turpentine and acetylene (prepared by the reaction between calcium carbide and water) in three separate test tubes. To each of these hydrocarbons, add a few drops of 3% solution of bromine in carbon tetrachloride, stopper the test-tubes and shake well for sometime.

OBSERVATION:

Colour of bromine is discharged in the test-tubes containing ethylene or turpentine and acetylene.

Activity-2:

Fill three test-tubes with the three hydrocarbons Viz. methane/kerosene in one, ethylene/turpentine in the second and acetylene in the third.

Add a few drops of acidfied 1% potassium permanganate solution to each of the test-tubes and shake well.

OBSERVATION:

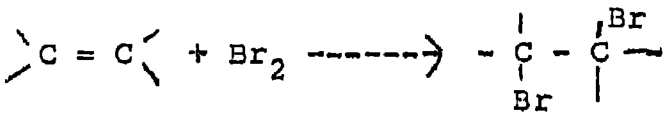
The permanganate colour is discharged in test-tubes which contained ethylene/turpentine and acetylene.

WONDERING WHY ?

Why ethylene/turpentine and acetylene are able to discharge the colour of bromine and also of permanganate ?

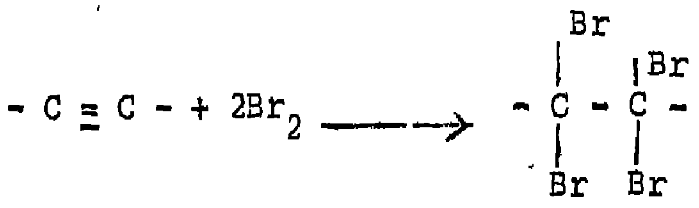
POSSIBLE EXPLANATION:

Investigations on the structure of ethylene/ turpentine show the presence of a double bond (unsaturation). The double bond is made up of a strong bond and a weak/bond . When Br_2 molecule reacts with unsaturated molecule, weak bond breaks and the Br_2 is added on to the alkene at the site of the double bond. Since bromine is used up in the addition reaction, colour of bromine is lost.



$$>C=C< + Br_2 \longrightarrow -\underset{Br}{\overset{|}{C}}-\overset{Br}{\underset{|}{C}}-$$

Similarly, acetylene has a carbon-carbon triple bond (unsaturation). This triple bond is made up of one strong bond and two weak bonds. When Br_2 molecule reacts with acetylene, the weak bonds are broken as in the case of ethylene.



$$-C\equiv C- + 2Br_2 \longrightarrow -\overset{Br}{\underset{Br}{C}}-\overset{Br}{\underset{Br}{C}}-$$

Ethylene/turpentine and acetylene both being unsaturated are reactive. They are easily oxidised by acidified permanganate.

GENERALISATION:

(i) Hydrocarbons can be classified into saturated and unsaturated hydrocarbons.

(ii) Unsaturated hydrocarbons are more reactive than saturated hydrocarbons.

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CLASSIFICATION OF FOOD MATERIALS

Dr.B.K.Praharaj

OBSERVATION:

Good food is very much necessary for the growth and development of all living systems. Energy is required to carryout various functions of the body and this energy comes from the food we take. The food materials contain mainly carbohydrates oils and fats, proteins, mineral salts and vitamins.

IDENTIFICATION OF THE PROBLEMS:

How to detect the presence of carbohydrates, proteins and oils and fats in the various food materials we consume in our daily life ?

GATHERING INFORMATION:

- Carbohydrates are broadly classified into monosaccharides (e.g. glucose, fructose etc.) oligosacharides (e.g. maltose, sucrose etc.) and polysaccharides (e.g. starch, cellulose etc.).
- All carbohydrates can be detected by Molisch's test (Add a few drops of alcohol solution of α - naphthol to a solution or suspension of carbohydrates in water. Slip about 1ml Conc.

H_2SO_4 along the sides of the test-tube when a violet purple coloured ring is obtained).

- Proteins are made up of a very large number of amino acids.
- Presence of a protein can be detected by a biuret test (Dissolve/suspend the given protein in sodium hydroxide solution and to this add drops of a very diluted solution of copper sulphate when a bluish-violet, violet or pink colour is obtained.
- Oils and fats are esters of glycerol and higher fatty acids.
- Oils and fats can be detected by acrolein test (Heat the oil/fat with potassium bisulphate. A pungent irritating odour is obtained.

HYPOTHESIS:

The presence of carbohydrates/proteins/oils and fats in various food materials can be detected by performing (i) Molisch's test (ii) Biuret test and (iii) acrolein test,

DESIGNING ACTIVITIES TO TEST THE HYPOTHESIS:

Perform all the three tests on the available food materials and note down the observations in a tabular column as shown above.

Food material	Molisch's test	Biuret test	Acrolein test
1. boiled rice extract			
2. boiled pulses extract			
3. proteinex powder			
4. Groundnut oil			
5. Vanaspathi (Dalda)			

WONDERING WHY ?

i) Why carbohydrates give violet/purple colouration with Molisch's reagent ?

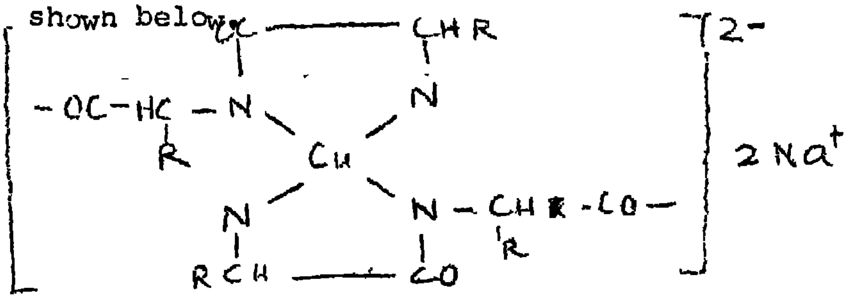
ii) Why proteins give violet/purple colouration with NaOH and $CuSO_4$?

iii) Why oils and fats on heating with potassium bisulphate give a pungent irritating odour ?

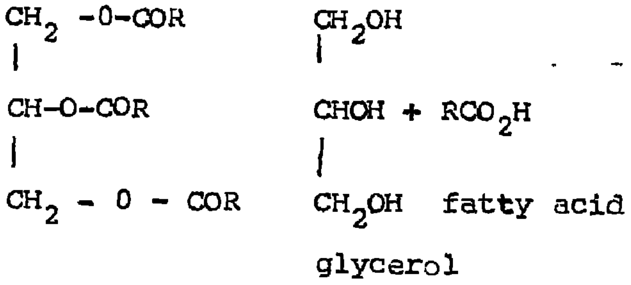
POSSIBLE EXPLANATIONS:

i) Carbohydrates on treatement with concentrated sulphuric acid undergo dehydration resulting in a compound called furfural or its hydroxy derivative. The compound with α-naphthol forms a violet coloured condensation product.

ii) Proteins contain long chains of amino acids combination of one amino acid (Compound containing an amino group + NH_2 and an acid group - COOH). With the other amino acid results in a peptide band - NH-CO-. This peptide links are responsible for the biuret test. The structure of the coloured product formed at a section of the protein chain is shown below.



iii) On heating, oils/fats undergo partial hydrolysis and the resulting glycerol is dehydrated by potassium bisulphate to give acrolein or acraldehyde.



$$\begin{array}{ll} CH_2-O-COR & CH_2OH \\ | & | \\ CH-O-COR & CHOH + RCO_2H \\ | & | \\ CH_2-O-COR & CH_2OH \quad \text{fatty acid} \\ & \text{glycerol} \end{array}$$

$$\text{glycerol} \xrightarrow[KHSO_4]{-H_2O} CH_2=CH-CHO \text{ (acrolein)}$$

GENERALISATION:

Carbohydrates, proteins and oils/fats in food materials can be detected by Molisch's test, biuret test and acrolein test respectively.

DIFFUSION OF GASES

Mrs. N.T. Chhotray
RCE, Bhubaneswar

When a bottle of NH_3 or HCl is opened in one corner of a room or a bottle of perfume is opened or agarbati sticks are lighted, We get the smell at the other corner of the room. How does it happen ? Obviously the molecules connected with these characteristic smells can diffuse through air and reach us. Kinetic theory of gases assume that molecules in the gaseous or vapour state are at constant motion and would tend to occupy the entire space available to them.

- When a drop of ink or a few crystals of $KMnO_4$ are placed in a beaker of water, the water gets uinformerly coloured after sometime which proves diffusion can occur also in a liquid.

IDENTIFICATION OF A PROBLEM:

Do all molecules irrespective of their size (mass) diffuse at the same rate? If not there is any relation between a mass of the molecules and the rate of diffusion.

COLLECTION OF FACTS:

- At a given temperature, all gases have the same average kinetic energy.

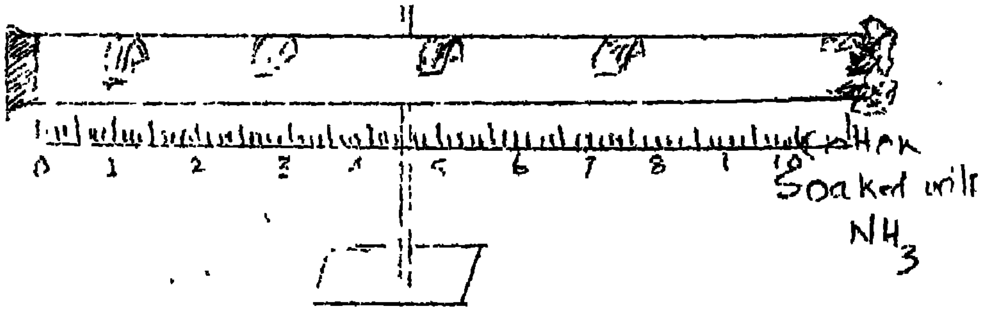
- masses of molecules of different gases are different.

HYPOTHESIS:

- Heavier molecules will have smaller average velocity than the lighter molecules and will diffuse at a slower rate.

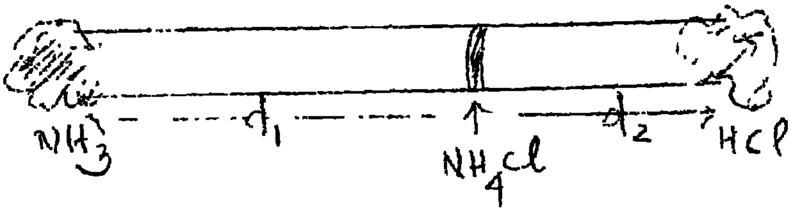
EXPERIMENT TO TEST THE HYPOTHESIS:

A long wide tube about 25cm is fixed on a stand. A glass rod with moist litmus (red) flaps at regular intervals is carefully inserted into the tube. One end may be closed with a stopper. The other end is pluged with cotton soaked with NH_3 solution and the stop watch started. NH_3 vapours will diffuse and turn the red litmus papers blue one after another. The times when the changes occur are noted. Distances of the flaps from one end can be read from the scale placed above the tube.



- The experiment is the repeated with blue litmus paper and cotton soaked with dilute HCl.
- Distances Vrs time can be plotted to determine average rate at which NH_3 and HCl diffuse and rate of diffusion can be calculated.

EXPERIMENT-2



A long wide tube is taken. At one end cotton pad soaked with NH_3 and at the other end cotton pad soaked with HCl are placed simultaneously. The tube is allowed to stand for sometime when a ring of NH_4Cl is formed in the tube. Time taken for the ring to be formed can be noted. Distances d_1 and d_2 can be measured.

Rates of diffusion can be calculated: r_1/r_2 can be calculated and compared with M_2/M_1 where M_1, M_2 are the molecular masses of NH_3 and HCl.

CONCLUSION:

Rate of diffusion is found to be inversely proportional to the molecular mass of the substance.

PREPARATION OF CHLORINE

Sri Biswanath Muduli

There is a magical gas which appears greenwish-yellow and it turns coloured flowers into white flowers and white paper (starch-iodide paper) into a coloured paper. This greenwish-yellow gas which bleaches moistened flowers and turns starch-iodide paper blue has the formula 'Cl_2' (Chlorine). How to prepare chlorine gas in the laboratory? Compounds containing 'Cl' could be the possible source of this gas.

Some compounds containing 'Cl': NaCl, KCl, $KClO_3$, HCl, $MgCl_2$, $CaCl_2$ etc. How to get 'Chlorine gas from compounds containing 'Cl' atoms in combined form?

Activity-1:

Heat each of the above mentioned substances separately in a test-tube and test for the liberation of chlorine gas.

POSSIBLE OBSERVATION:

None of the salts used liberate Cl_2 on heating.

Inference: Salts like NaCl, KCl, $KClo_3$, $MgCl_2$ $CaCl_2$ or conc HCl do not liberate Cl_2 on heating. Adopt a process which can breakdown the molecule KCl into K and Cl, NaCl, into Na and Cl etc. Such a process could be electrolysis.

Activity-2:

Electrolyse Conc HCl, strong aqueous solutions of NaCl, KCl, $MgCl_2$ and $CaCl_2$ using a beaker, graphite electrodes and 3V dry cells.

OBSERVATIONS:

In each case, chlorine gas is liberated at the +ve electrode i.e. anode.

WONDERING WHY:

Why chlorine gas is liberated always at the anode ?

POSSIBLE EXPLANATIONS:

Aqueous solutions of HCl, NaCl, KCl, $CaCl_2$, $MgCl_2$ contain chloride ions (Cl^-). When electricity is passed through the solution, negatively charged chloride ions drift towards positive electrode (anode) and get converted into chlorine atoms by the loss of electron.

At anode: $Cl^- \longrightarrow Cl + e^-$

$$Cl + Cl \longrightarrow Cl_2 \text{ (gas)}$$

Since this process involves less of electrons, oxidation is taking place at the anode.

HYPOTHESIS:

Chlorine can be prepared by the oxidation of chlorides.

FURTHER EXPERIMENTATION TO TEST THE HYPOTHESIS:

A few more chemical processes (other than electrolysis) which involveoxidation have to be tried on chloride salts.

Activity-3:

Heat a mixture of each of the above chloride with Conc. H_2SO_4 and MnO_2 (for oxidation) and test the gas liberated in each case for chlorine.

POSSIBLE OBSERVATION:

Chlorine gas liberated.

Activity-4:

Repeat the activity 3 using $KMnO_4$ (oxidising agent) instead of MnO_2.

OBSERVATION:

Chlorine is liberated in each case.

GENERALISATION:

Chlorine is prepared by the exidation of chlorides.

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POLLUTION OF AIR

Dr.Sura Prasad Pati

PROBLEM:

Dense fogs at industrial areas, airports, highways and in cities like Delhi, Calcutta, Bombay, reducing visibility to a few metres only, leading to accidents, preventing landing of air crafts are often reported, perticularly in winter. What cause the haze or smag (smoke + fog = smag) as it is known ? Why they are observed at such places? What can be done to prevent it ?

COLLECTION OF DATA:

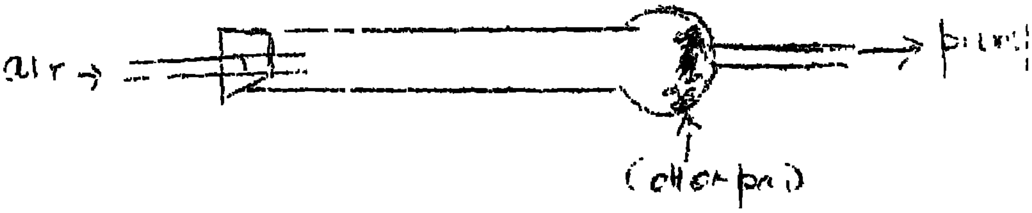
- Fogs are produced when large masses of air in contact with sea or colder earth surface so, that the tiny water droplets formed remain suspended in the air.
- The droplets form on tiny dust particles in the air.
- Where dust concentration is high fogs can form at low humidities (even as low as 65%).
- Dust particles have high affinity for water and causes droplets to grow and fogs become thicker.

- Dust particles come largely from the smoke and fumes produced from combustion of fuels (Coal, Petrole and kerosene) in power plants, industries).

EXPERIMENT TO SHOW SMOG FORMATION:

- Burn a small amount of sulphur or red phosphorus in a deflagerating spoon inside a gas jar.
- Add a few cc of water into the jar, shake well, What do you find ? (Tiny unburnt sulphur and phosphorus particles form the dust which attracts the water molecules.

EXPERIMENT TO SHOW PARTICLES OF DUST IN AIR:



(1) Deposits of dust particles will be seen on the cotton.

(2) Dust particles can be seen when sun light enters through a small opening into a dark room or torch light is switched on in the dark.

FOLLOW UP DISCUSSION:

Formation of fog and cloud can be discussed. Fog in combination with smoke coming out of our factories, automobile exhausts, aircrafts, locomotives is known as "smog". Dust particles from factories as cement, asbestos, particles of carbon and sulphur from burning of fuels have high affinity for water and cause the droplets to grow and the fog become thicker. This thick fog will not allow the smoke to escape and visibility will fall.

Our industries are adding tons of carbon monoxide, SO_2, oxides of nitrogen (automobile engines), hydrocarbons in addition to particulate matter. All these gases are potential health hazards carbon monoxide being a poison. The presence of these contaminants in such quantities that they become injurious to life or to property is called pollution.

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STATES OF SULPHUR

Dr.Mrs.J.Mohapatra,
RCE, Bhubaneswar

- Solids melt when heated and liquids vapourise when further heated. On cooling the reverse process occurs.
- When a solid is converted into a liquid it becomes more mobile and starts flowing.
- Sulphur, phosphorous, iodine are nonmetallic elements which occur in the nature as solids .

IDENTIFICATION OF A PROBLEM:

- Do these Also behave in the same manner towards heat ? Let us find out:

TEACHER SUGGESTED ACTIVITY:

Take a small amount of sulphur in a hard glass test tube and gently worm till it melts. Note the temperature when melting starts. Now further heat and record the changes observed.

OBSERVATION .

- When sulphur is heated in a test tube the yellow solid melts at a temperature of about 115°C to form an orange brown liquid, which when the test tube is tilted flows easily down the side.

- Then as the temperature of the molten sulphur is further raised the colour of the liquid darkens to deep red.
- At about 160°C the liquid is very viscous and cannot be poured down the side of the test tube.
- As heating is continued, the liquid turns dark brown and becomes mobile so that it can be poured down the side of the tube again.
- On further heating sulphur boils.
- If boiling molten sulphur is poured into cold water, it sets into a solid as it is cooled by the water. The solid is dark brown and is soft like a chewing gum. If it is kept for a few hours, it becomes hard and starts and turn yellow once again.

EXPLANATION:

The ways in which sulphur atoms are joined together at the various stages of heating are different. Sulphur is a molecular solid, the molecules consisting of eight atoms joined in a puckesed' ring.

In the solid the rings are held together by Vander Waals forces. When the solid is heated energy is fed into the crystals and the forces are overcome. The sulphur melts the rings are able to move. The rings can easily pass over each other and the newly melted sulphur is therefore runny.

As the heating continues the rings absorb more energy and some split at one point or other forming short chains of eight atoms. At this stage there is not enough thermal motion to prevent these short chains joining to form longer ones. The long chain becomes twisted and tangled together so that the liquid does not flow easily. This corresponds to the dark red extremely viscous liquid which is obtained at 160°C.

As more energy is given, to the liquid, the chains of sulphur atoms break up, forming much shorter length. These cannot be twisted or tongled together and can therefore easily pass over each other, the liquid becomes mobile again.

When boiling molten sulphur is poured into cold water, it is caught in the condition it was in just before it was poured into the water. It consists of tangled chains which can push over each other. As the plastic sulphur stands however these chains gradually reform the original eight membered rings and the solid starts to become crystalline again with corresponding changes in strength and in colour.

FURTHER EXPERIMENTATION:

Solid iodine may be taken and the effect of heat can be studied.

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TEACHING OF SCIENCE THROUGH EXPERIMENTS – A PROCESS APPROACH

Date:- 28.11.94 to 3.12.94 Venue:-RCE,Bhubaneswar

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6. Dr.(Mrs) J.Mohapatra,
   Lecturer in Chemistry,
   RCE, Bhubaneswar.

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PROGRAMME DIRECTOR'S REPORT

The Workshop was inaugurated on 28th November,94. Our Principal Dr.S.T.V.G.Acharyulu and Prof.Dr.N.Khattar, in their inaugural and presidential address emphasised the importance and place of experiments in teaching Chemistry to develop the spirit of inquiry amongst the children. Though 20 participants were invited, 10 each from Bihar and Orissa only four from Bihar and eight from Orissa attended the Programme.

The inauguration was followed by a brief discussion on the objectives of the Programme and consequent planning. From the afternoon of 28th to 1st afternoon, the faculty members presented model lessons illustrating the process approach of teaching Chemistry. The experiments planned were carried out by the participants.

On 1st afternoon, the participants were asked to form small groups and develop lesson plans, design and tryout experiments, illustrating process approach for presentation. It is worth mentioning that the participants sincerely got into the job and even did a bit of home work to present their lessons next morning. The lessons presented by the participants were discussed and final write ups were made incorporating the suggestions made during discussion.

Evalu[illegible] programme has brought out to following deficiencies ;

(i) Though the programme was interesting and worth attempting, the duration was short.

(ii) Library facilities should have been provided

We take note of these deficiencies for future programme.

Finally though achievement of a great success can not be claimed, it was the consensous opinion of the participants that a modest begining has been made. We hope, the participants will carry forward the ideas as key resource persons in their turn.

I am grateful to my Principal Dr.Acharyulu and the Professor Dr.Khattar for extending all facilities and above all their constant encouragement through their kind presence on such occasions.

I thank all the participants for their active participation and sincerety without which it would have not been possible to achieve whatever success it has achieved.

I also thank my colleagues and other staff members of the Departments and the College for their kind cooperation.

National Institute of Education
Library & Documentation